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PE 2014



FOUP (Pod) contamination control solutions for 200 mm,
300 mm and 450 mm substrates

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Agenda

- Entegris introduction
- FOUP (Pod) Contamination Control Solution
 - Advanced Purge
 - EBM Material
- Purge test results
- M200 SMIF pod
- Summary



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Entegris at a Glance

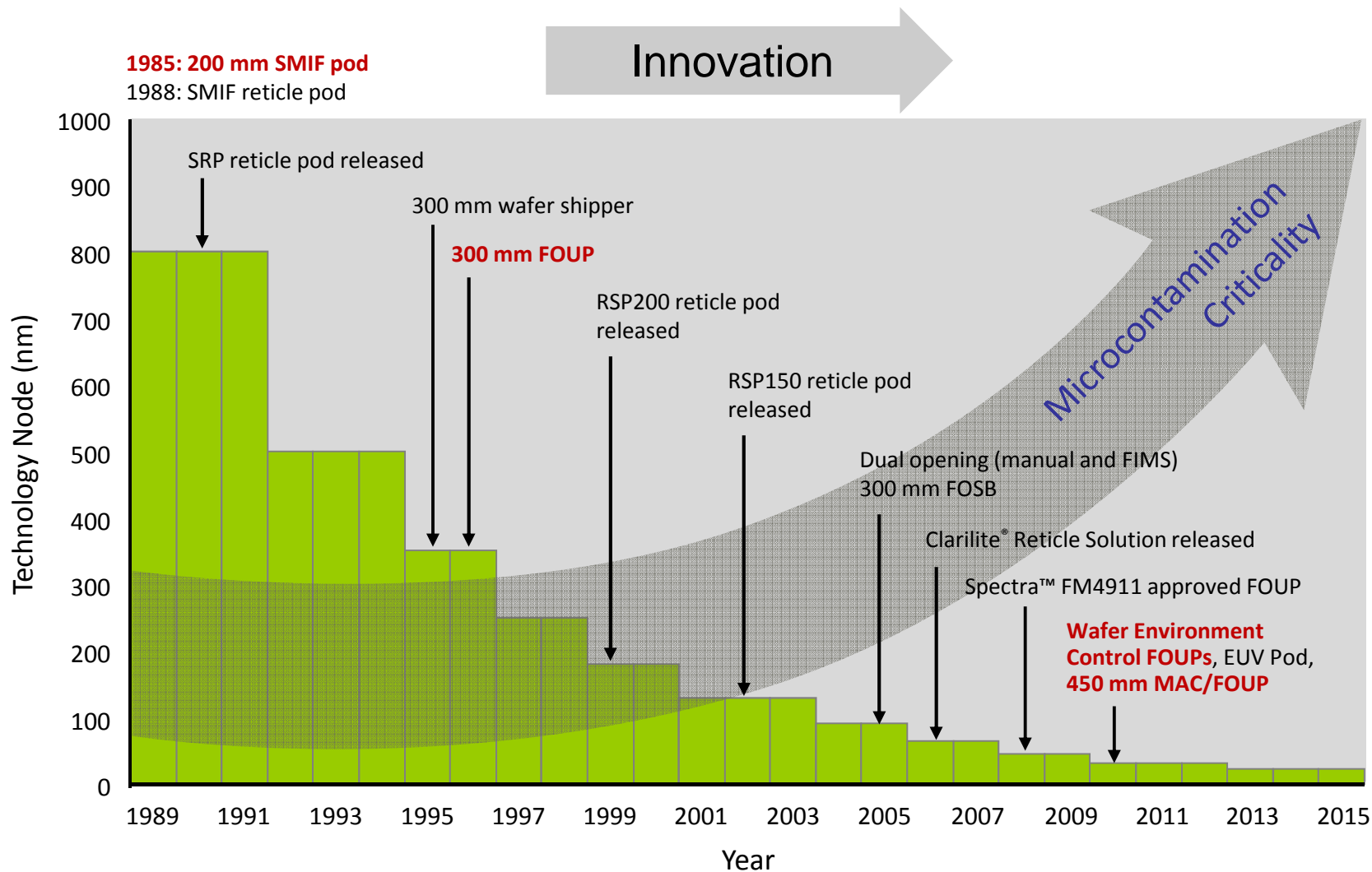
- Market leader in contamination control, critical materials handling and advanced process materials for semiconductor and other high-tech industries
- Fiscal 2013 pro forma sales of \$1.1 billion
- 3,500 employees worldwide
- 618 U.S. patents and 1073 patents in other countries
- Headquartered in Billerica, MA with a global infrastructure of manufacturing, service and research facilities in the U.S., Malaysia, Singapore, Taiwan, China, Korea, Japan, Israel, Germany and France
- Publicly traded on NASDAQ under ENTG



Entegris Milestones

1966	Founded as Fluoroware, Inc.
2000	IPO
2005	Merges with Mykrolis, previously part of Millipore
2007	Acquires Surmet's Semiconductor Coatings Business
2008	Acquires Poco Graphite
2009	Acquires PureLine
2012	Acquires EPT
2013	Acquires Jetalon Solutions
2014	Acquires ATMI, a leading provider of advanced materials

Wafer and reticle handling solutions have kept pace with each advancement in IC manufacturing



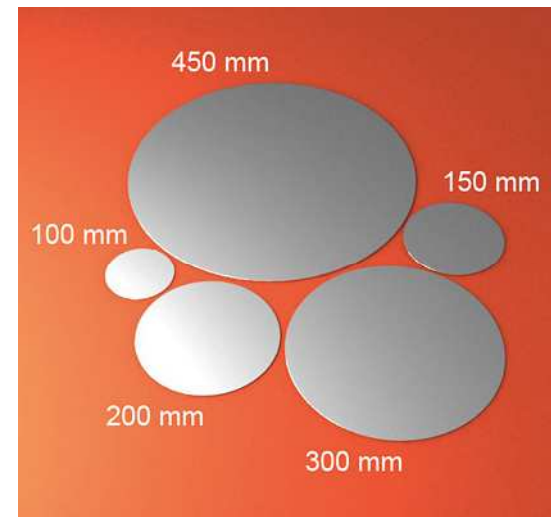
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Why is Microenvironmental Control Critical?

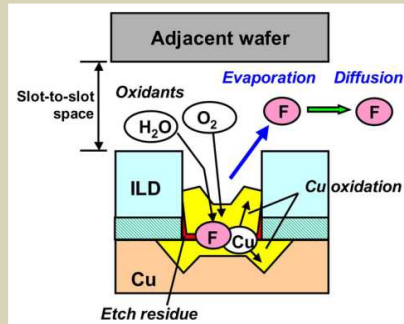
- Faster chips, greater performance
- New processes and materials
- 45 nm and below processes
- New requirements:
 - Achieve very low contaminant levels (AMCs, O₂, RH)
 - Maintain low levels for extended period of time (w/o maintenance purge)
 - Better purge uniformity across wafer slots
 - Maintain low level when FOUP door is open
- Advantages:
 - Higher yield
 - Smaller wafer-to-wafer variation
 - Higher tool throughput
 - More flexible WIP management (extended queue time)

45 nm 32/28 nm 22/20 nm 16/14 nm 10 nm

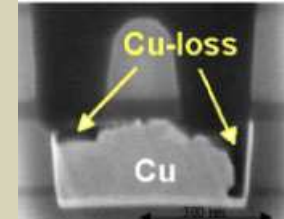
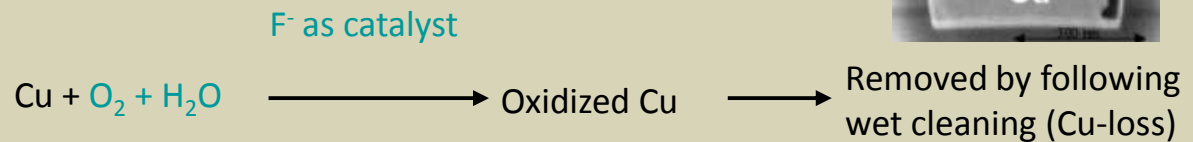
Manufacturing / Development Research



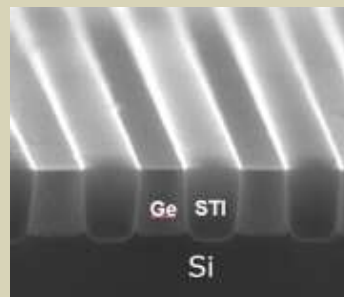
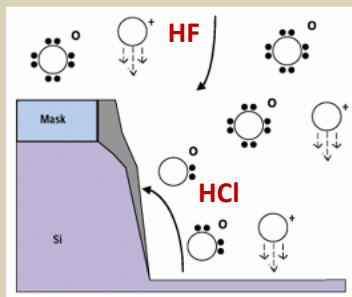
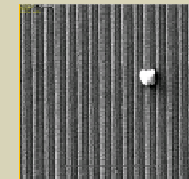
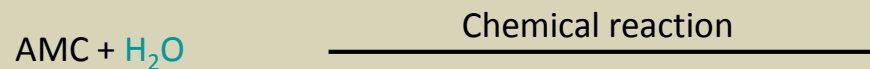
Why H₂O and O₂ Control are Critical



Copper Corrosion*

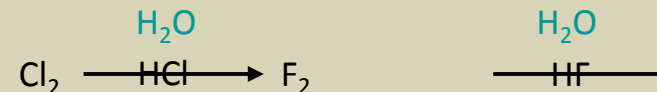


Defect / Crystal Growth



Excessive Etch

- F₂ and Cl₂ are common gases used for etching
- Residual F₂ and Cl₂ will react with H₂O and form HF and HCl that will lead to attack of the edge profile



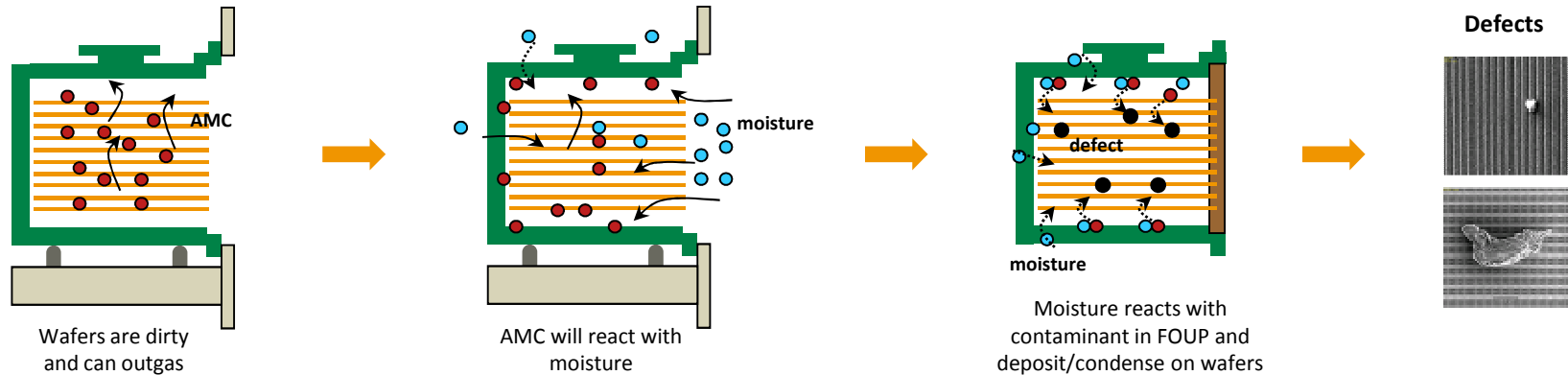
*Source: T. Kamoshima, et al., "Controlling ambient gas in slot-to-slot space inside FOUP to suppress Cu-loss after dual damascene patterning," IEEE Trans. Semicon. Manufact., vol. 21 (Renesas & Hitachi).

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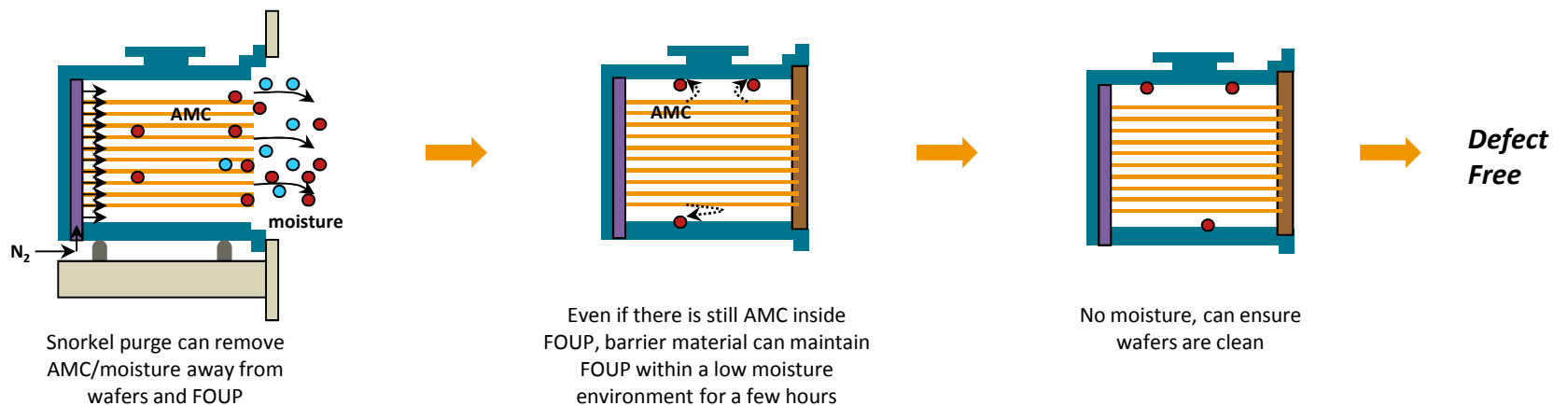
Crystal Defects

- Using EBM FOUPs and purge can effectively help with defect reduction

PC FOUP without purging



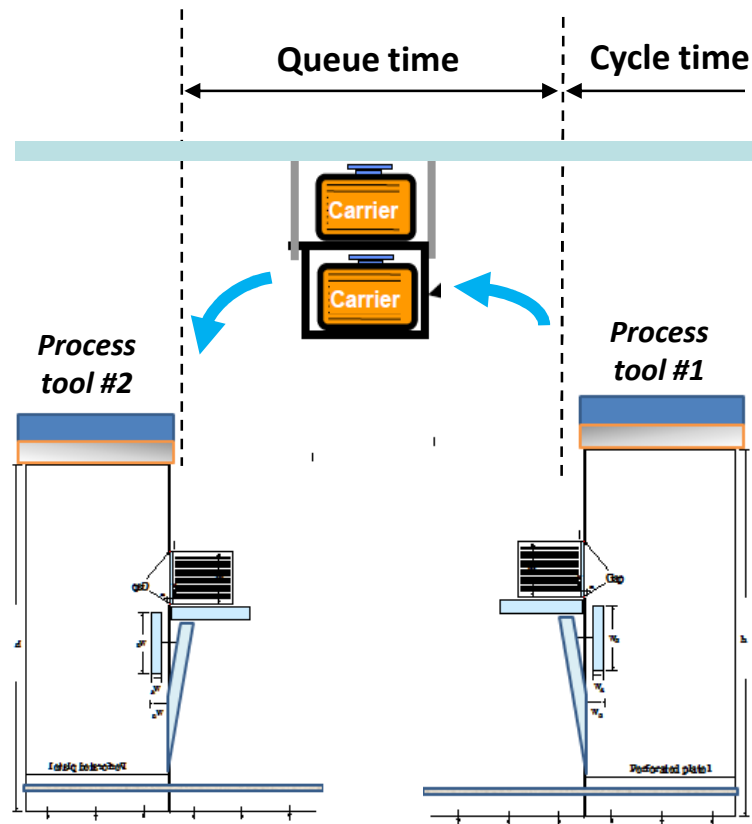
Entegris barrier material FOUP with snorkel purge



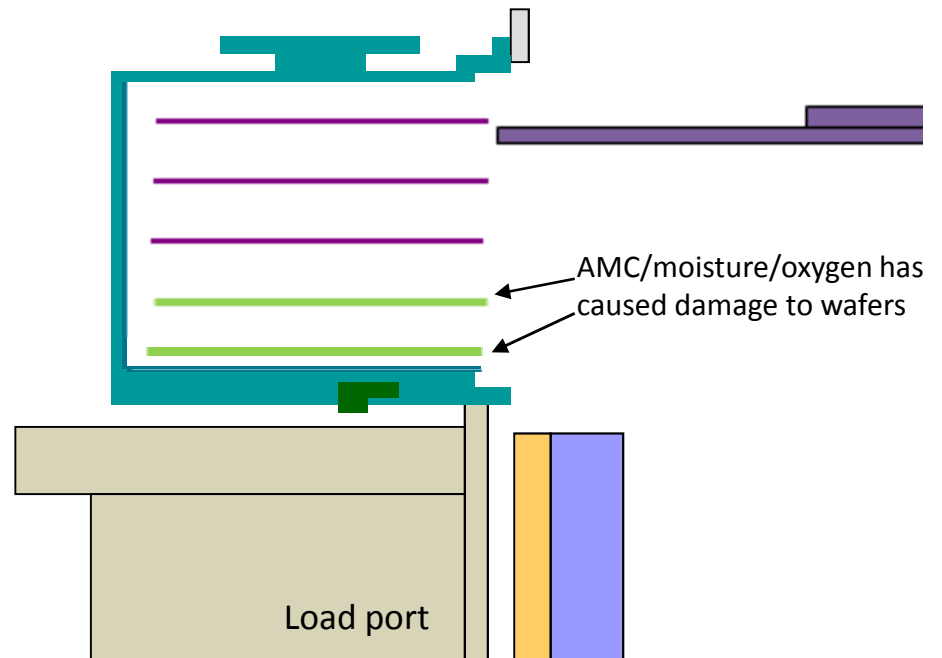
Is Queue Time Control Enough?

Wafers are idling longer on load port during process!

So, LP purge is needed to protect your wafers



Wafers might have been damaged while waiting for other wafers to be processed, so no matter how you control the queue time, it might not work



1. Wafers can be idle for 1–2 hours on single processing tool and defects can be formed during this time on load port
2. Therefore, N₂/CDA protected environment is strongly recommended

Advanced Purge Technology

For an effective purge



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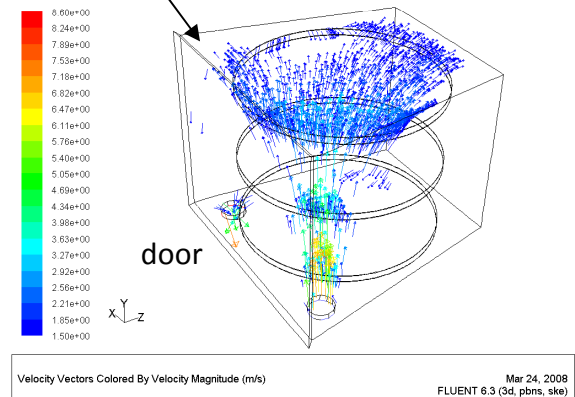
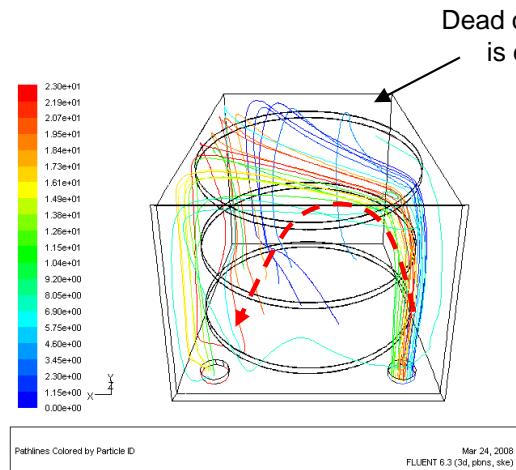
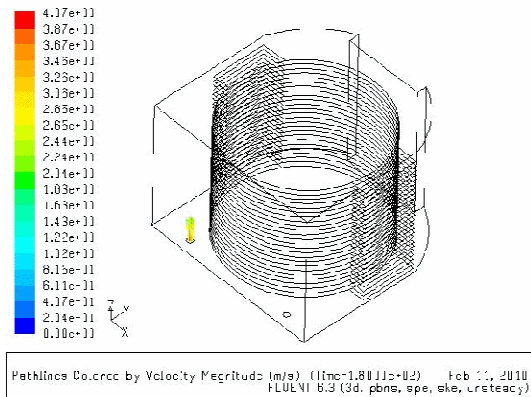
creating a material advantage



Traditional purge cannot meet your advanced process needs

1 inlet/1 outlet (front purge)

- Some purge gas will either flow directly from inlet to outlet or leak out from door, some dead zones are created
- Purge gas is difficult to go into the space between wafers, where RH/O₂ control is most needed

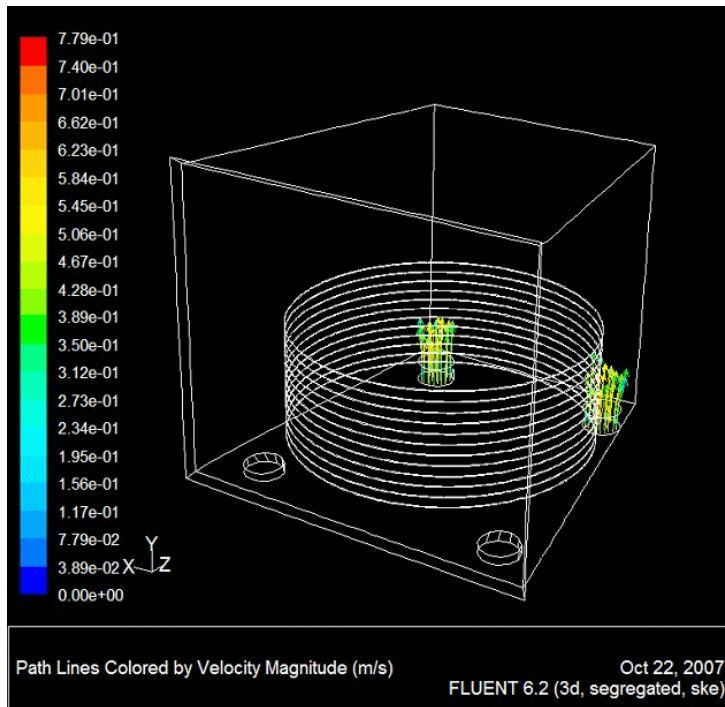


FOUP (1 inlet, 1 outlet = front purge)

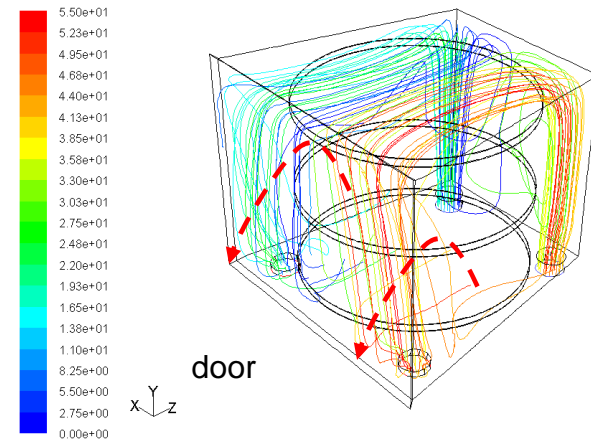
- Do you have particle issues?
 - On top wafer
 - Back of FOUP

Traditional purge cannot meet your advanced process needs

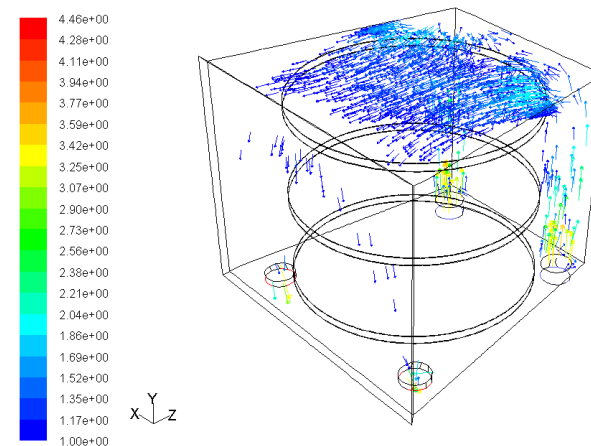
Improved Design: 2 inlets/2 outlets (rear purge)



- Flow is smoother → less particle trap
- 2 inlets/2 outlets can meet most of the application need



FOUP (2 inlet, 2 outlet)



Velocity Vectors Colored By Velocity Magnitude (m/s)

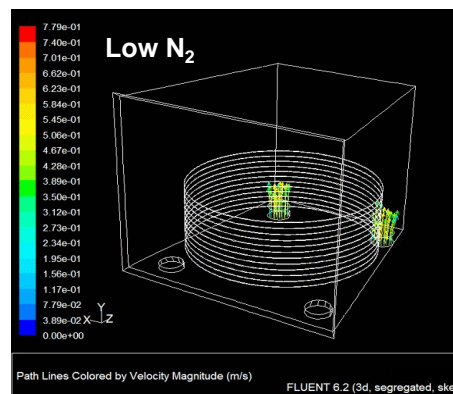
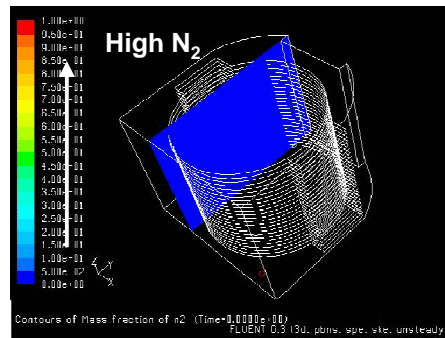
Mar 24, 2008
FLUENT 6.3 (3d, pbns, ske)

Basic Purge versus Advanced Snorkel Purge

No snorkel =

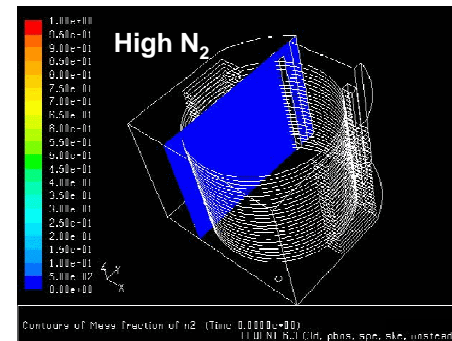
2 inlets from the back

- N_2 will not easily fill the spaces between wafers



With snorkel

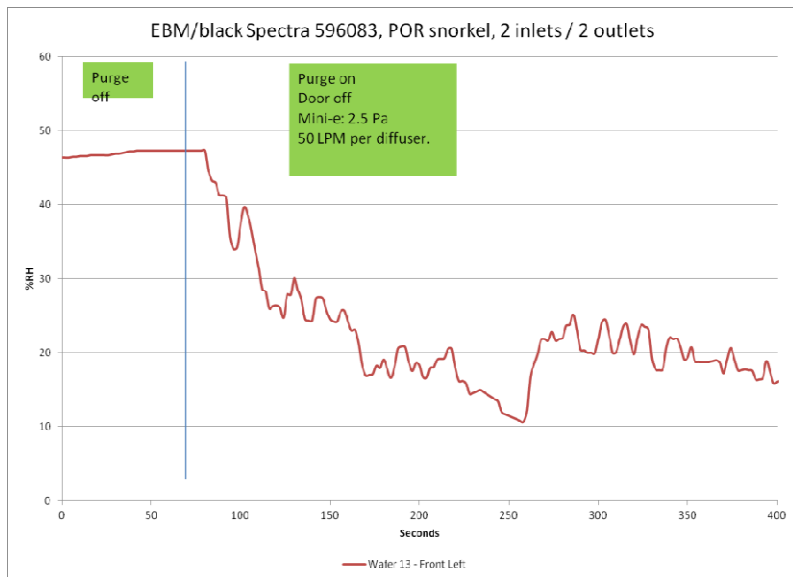
- N_2 can fill in the space between wafers faster



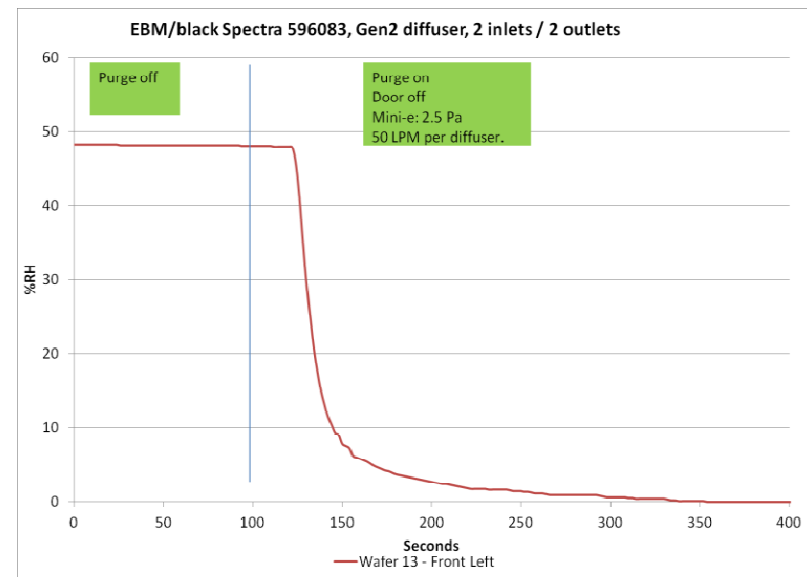
Snorkel can help drive purge gas into the space between wafers



Preliminary Door open Purge test results with XCDA[®] 50 L/min per diffuser



POR



Gen-2

Data for slot 13, front left

XCDA[®] is a trademark of Entegris, Inc.



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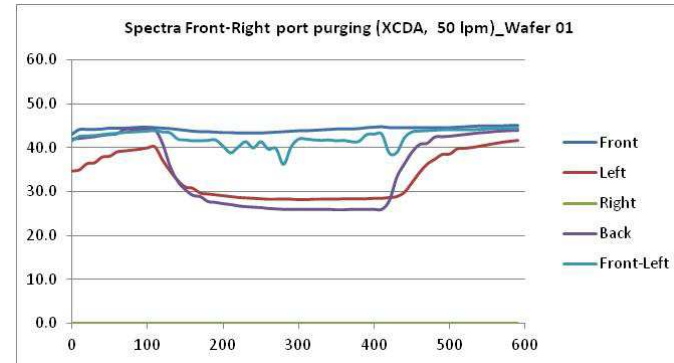
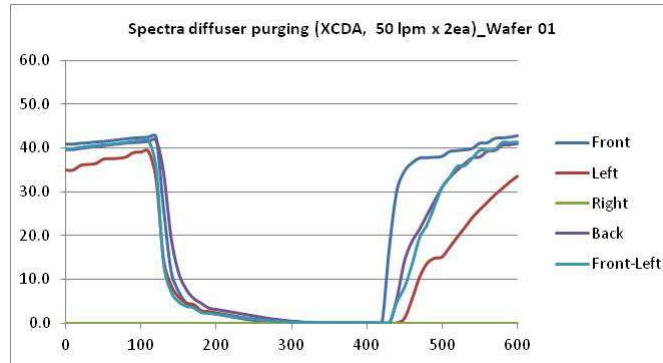
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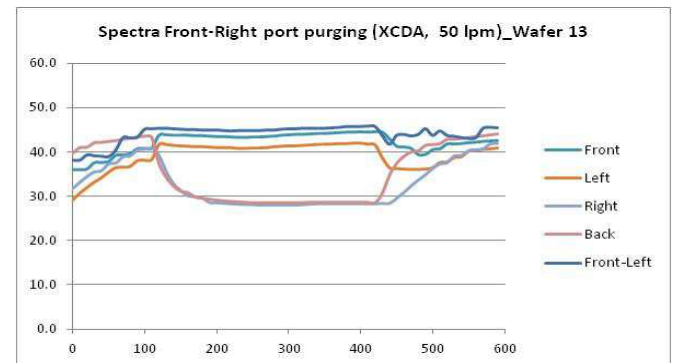
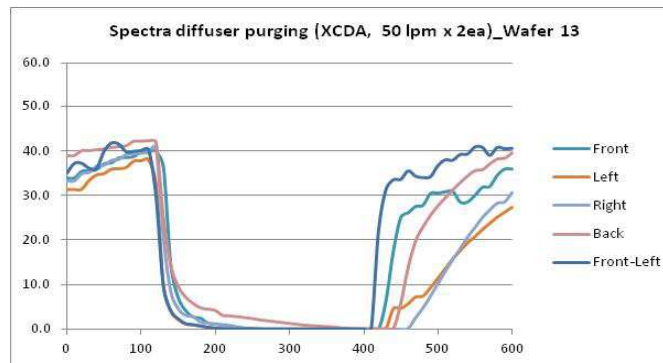


Four Port vs. Two Port Door Off Purging

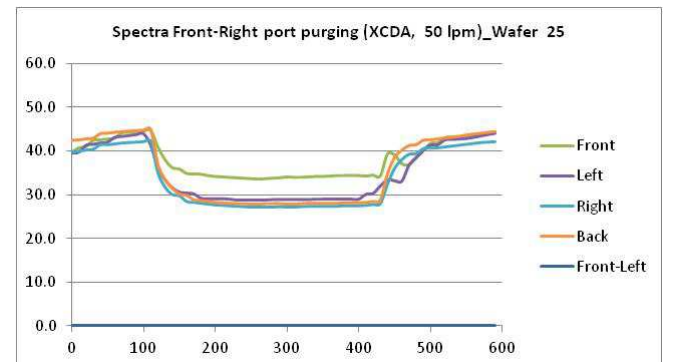
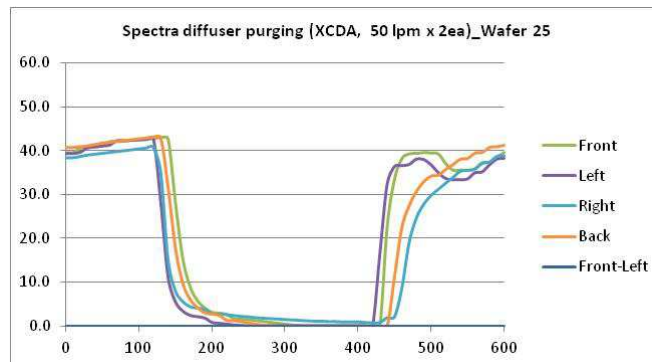
Slot 1



Slot 13



Slot 25



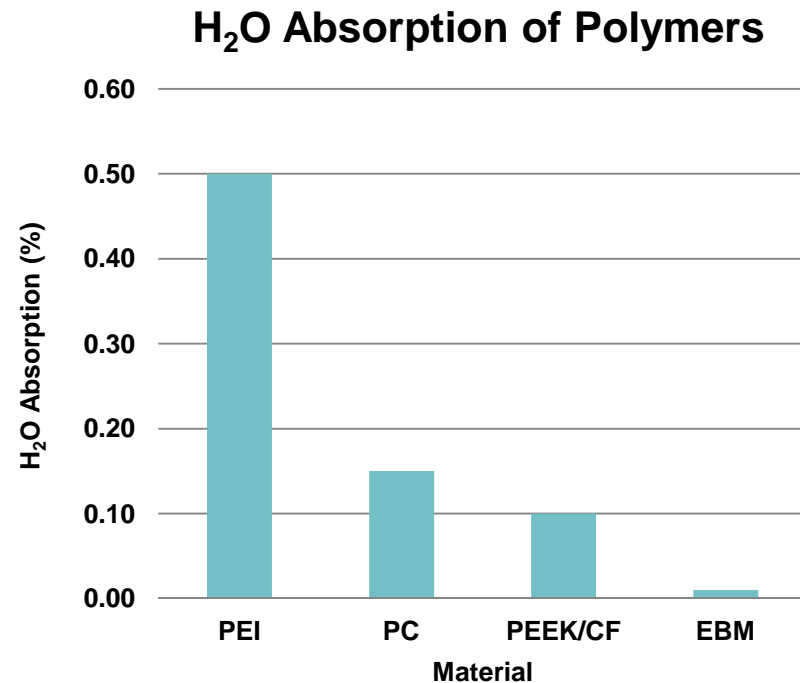
EBM Material FOUP for High End Processes

Maintain the purge results and extend queue time

EBM Material – Water Absorption Of Different Polymer Materials

- Materials that can absorb excessive amounts of water (PC, PEI or PEEK™), will heavily impact moisture recovery in a FOUP
- As a result, for purge application, constant or frequent purge is required if you want to keep the FOUP environment dry

PEEK™ is a trademark of Victrex plc.

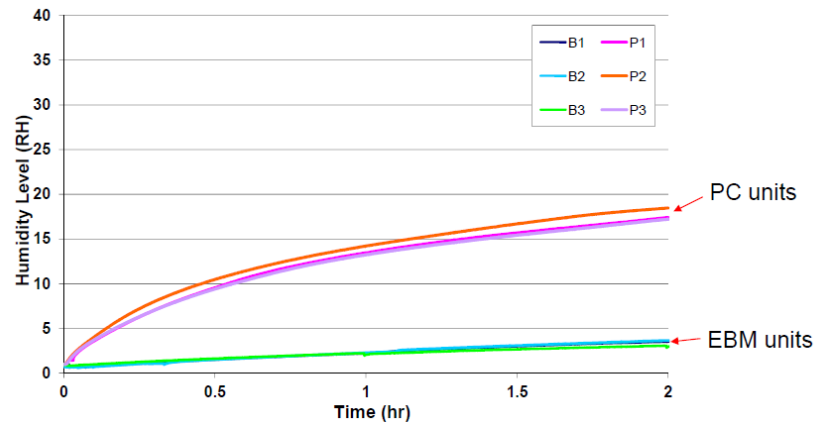


How EBM can help = low moisture and low AMC

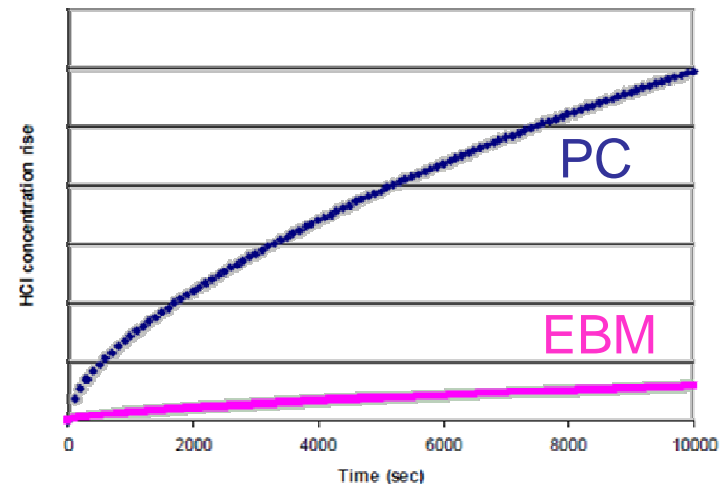
- EBM FOUP + purge can effectively extend queue time due to:
 - Moisture level can be maintained low (<15%) for more than 18 hrs after purge
 - HF/HCl/AMC absorption/desorption is much less in EBM FOUP than PC FOUP

Queue time can be extended and defect level can be kept low

Moisture



EBM desorbs much less HCl than PC



M200 SMIF pod update



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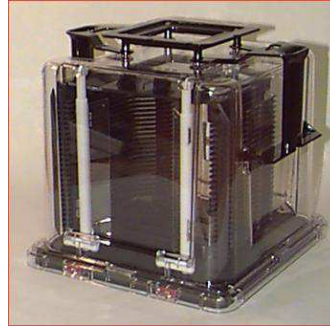

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200 mm SMIF pods EBM and purge options

Standard 200 SMIF pod developed in 1985 using PC material

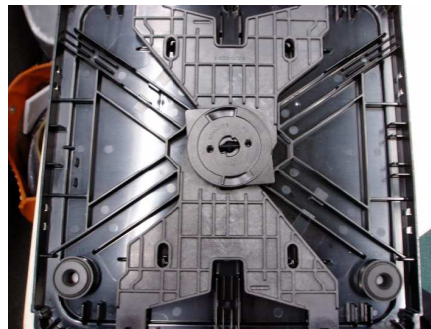
M200 style SMIF pod
A200 style SMIF pod



Advanced EBM/CNT
dome
EBM Amber dome
(M200 SMIF pod)



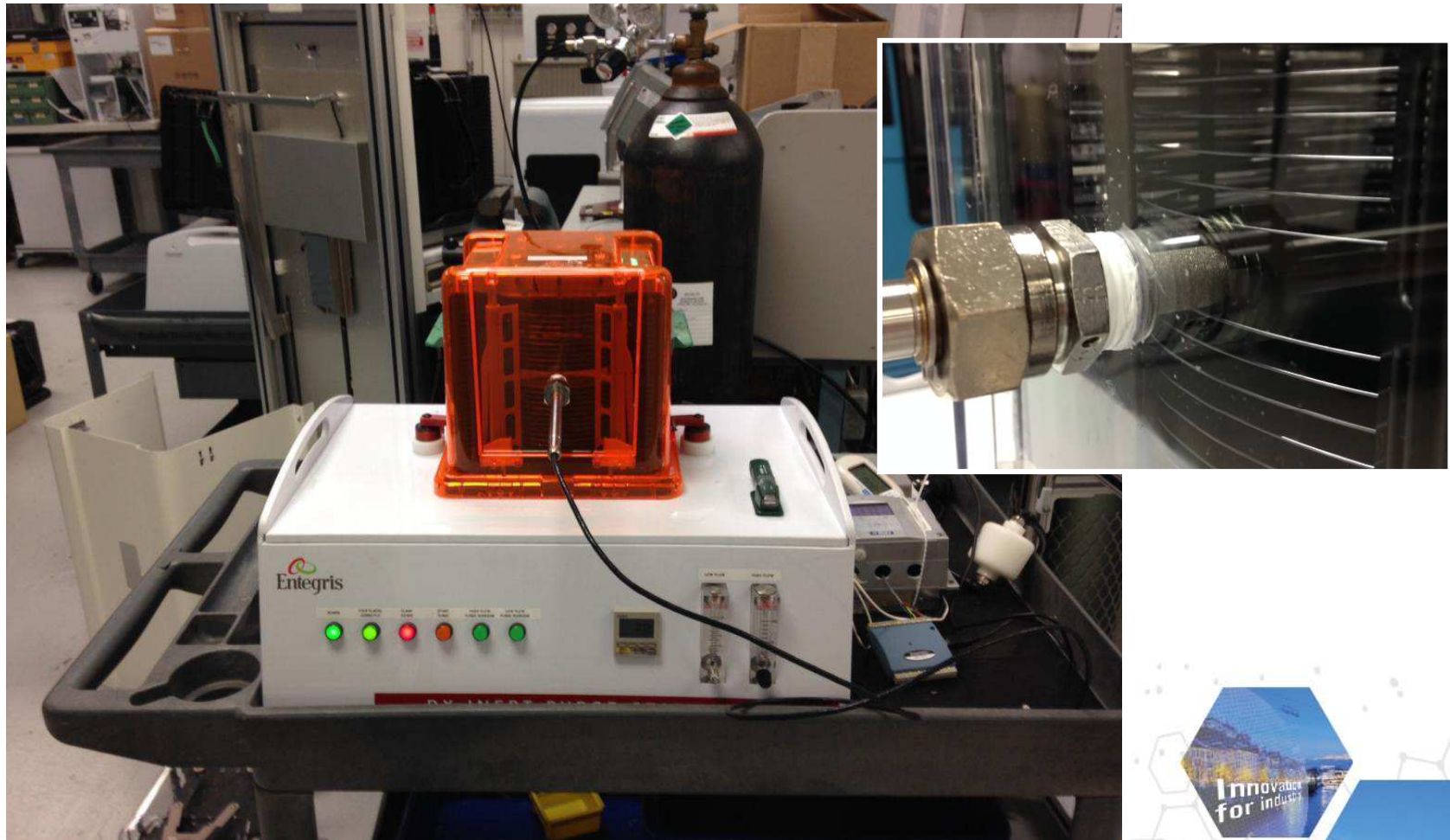
E200 purgeable SMIF
pod door
(EBM inner door)



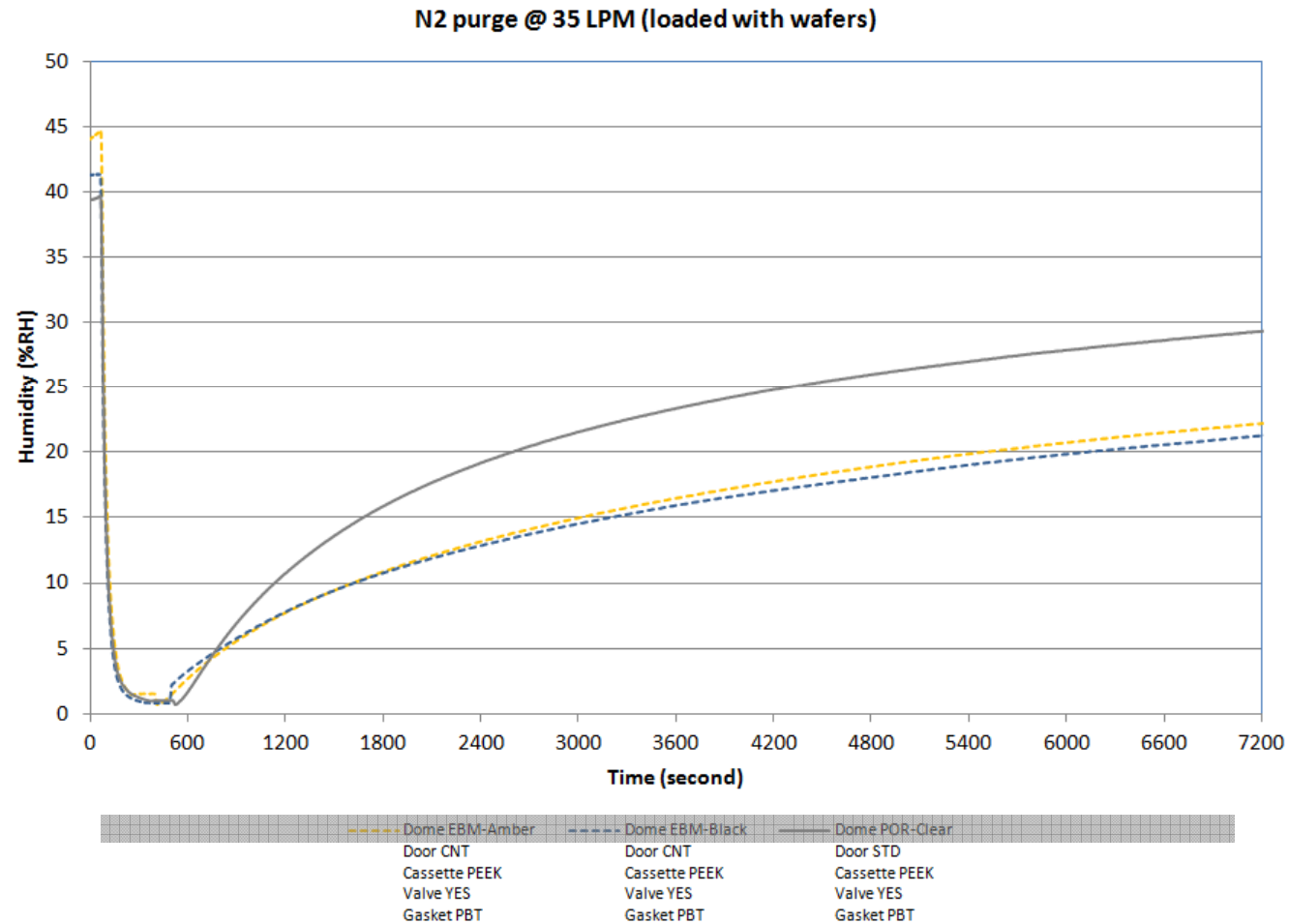
Inlet

Outlet

RH and Purge test setup



Results – POR (PC) vs. EBM SMIF pod



Summary contamination control solutions

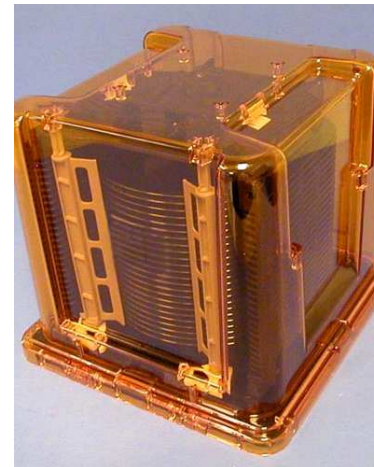
EBM material and purge

- Advanced (EBM)Entegris Barrier Materials
- Purge options standard or advanced diffuser
- Purge application using N₂, CDA or XCDA
 - Extend low moisture and low AMC environment control
 - Critical process steps/control wafer environment/yield
 - Proposed FOUP and pod environment control solution for your high end process

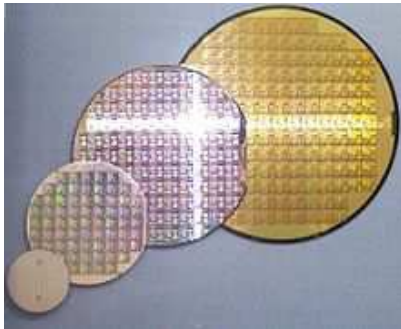
450 mm FOUP



300 mm FOUP



200 mm SMIF pod



Thank you for listening



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